Packet 5.2 - Traits & Genes Unit

First & Last Name: _____ Period/Hour:_____

NOTE: Packets are due after completing Part 5. Check each page to be sure all blanks are completed.

Driving Question: How are traits inherited from parents?

Anchoring Phenomenon: How do traits get passed from parents to offspring? And why are organisms slightly different from their parents and from each other? In this packet, we will focus on a black Labrador retriever named Zola, who gave birth to a wide variety of puppies. How is this possible? How did her genes get passed on to her puppies?

Deeper Questions

1. How do parents transfer their genes to their offspring?
2. How do reproductive cells (like sperm and egg cells) form?
3. Why do offspring look similar but not identical to their parents?

Schedule

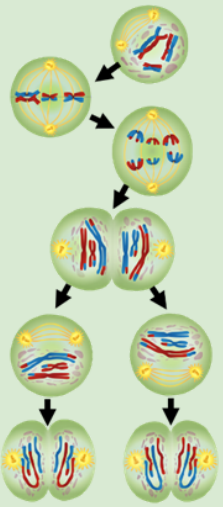
Part 1: Introduction
- Initial Ideas & Data Dive - Zola's Puppies
- Test Prep Activity
- Discussion & Developing Explanations

Part 2: Core Ideas
- Core Ideas & Revisions of Part 1 Explanations

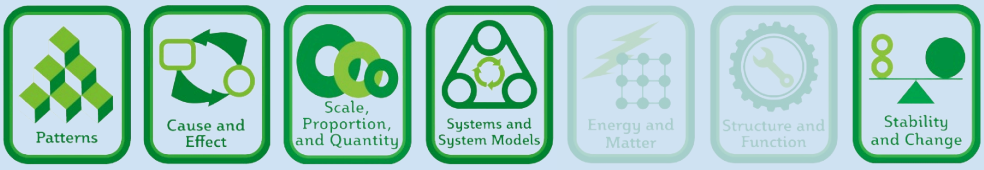
Part 3: Investigation
- Meiosis Simulation
- Meiosis Modeling

Part 4: Review & Assessment
- Ranking Your Readiness
- Formative Assessment & Mastery Check

Part 5: Life Connections
- Life Connections - Sex-linked Traits



NGSS Standards (*PEs* & *CCCs are summarized below. SEPs are noted throughout the packet*).
HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. HS-LS3-1 - Role of DNA/chromosomes as instructions for traits inherited from parents via meiosis. LS-LS3-3 - Predicting likelihood of different traits in a population/offspring. HS-LS1-4: How does mitosis and differentiation enable complex organisms?



Semester Schedule

5. Traits & Genes
5.1: What determines the traits of an organism?
5.2: How are traits inherited from parents?
5.3: Can we predict traits?
5.4: Unit Assessment

6. DNA & Proteins
6.1: What is DNA and how does it work?
6.2: How does DNA affect protein assembly?
6.3: Unit Assessment
6.4: How are genes modified? *(mini-unit)*

7. Mutations & Change
7.1: How does a protein get its shape & function?
7.2: How do mutations change genes & proteins?
7.3: How can mutations create new traits & species?
7.4: Unit Assessment
7.5: How Does Antibiotic Resistance Occur?

8. Biodiversity
8.1: How does biodiversity affect ecosystems? Why is biodiversity being lost?

These materials were partly developed with assistance from artificial intelligence.

Resource Links: Class Website; Core Ideas; Summary Video; Practice Test; Simplified Meiosis Image; Meiosis GIF; Cells to Gametes Image; Meiosis Video 1; Meiosis Video 2; Meiosis Simulation

Part 1: Introduction – Scientific Discoveries (5.2.1)

Overview: You will begin by discussing your initial ideas about how offspring inherit genes from their parents. You will then analyze data and work in teams to develop your initial explanations.

Initial Ideas - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Engaging in Argument from Evidence

A black Labrador retriever named Zola recently gave birth to a litter of puppies after mating with a yellow lab. What was surprising was this litter contained black, yellow, and chocolate labs. How could it be possible for a black lab and a yellow lab to produce three different kinds of Labrador puppies?

To learn more, use this link to view a news article. (Image source).

1. Three students shared their ideas. Do you agree or disagree with each student's claim?

- Avery: " I think that some puppies inherited the mother's genes, some inherited the father's genes, and some had mutations." *Agree / Disagree*
- Bristol: "I think that both parents had genes for all of these traits but whether or not the genes are used by a cell is completely random." *Agree / Disagree*
- Chandra: "I think that maybe some genes skipped a generation but I don't really understand what that means." *Agree / Disagree*

2. **Work in your small groups to discuss your ideas.** How are your ideas similar or different? Decide as a group whether each statement is correct (and why). Be prepared to present your ideas to the class.

Data Dive - *Complete the reading below. Use the space on the right to annotate the text by recording your ideas, highlighting important points, and recording questions as you are reading.*
SEP: Obtaining, Evaluating, and Communicating Information

Introduction: People have long noticed that offspring resemble their parents, but how this happens was poorly understood throughout most of history. Experiments over the years have helped scientists uncover the ways in which offspring inherit traits from their parents.

Preformism: At one time, some people believed that sperm cells contained tiny, fully-formed humans. This theory was called "preformism." They thought this preformed human grew inside the mother's egg cell and inherited their father's traits without change. However, this didn't explain why offspring also shared traits with their mothers, or why children were not identical to their fathers. Later, improved microscopes confirmed that sperm cells did not contain preformed babies.
(Image Source)

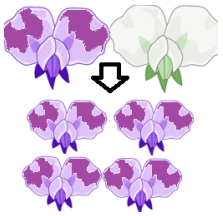
Driving Question:
1. How do offspring inherit the traits of their parents? *(Keep this in mind as your read & answer later)*

2. Summarize the claims, evidence, and reasoning for and against the idea of *preformism*.

Pangenesis Theory: Pangenesis was the idea that a parent's experiences could change their blood, altering the eggs or sperm. Some thought that activities like studying or exercise could result in smarter or more athletic children, and these changes would be recorded in particles in the blood. Francis Galton tested this by transferring blood between rabbits with different colored fur. If pangenesis were true, the baby rabbits should have had the fur color from the blood donor rabbit. Since this didn't happen, Galton's experiment helped disprove the pangenesis theory.

3. Summarize the claims, evidence, and reasoning for and against the *Pangenesis Theory*.

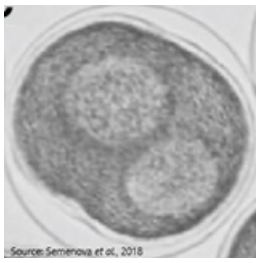
Mendel's Peas: It was once believed that offspring's traits were just a blend of their parents' traits. In the mid-1800s, Gregor Mendel studied heredity in pea plants and discovered that some traits, like flower color, followed predictable patterns. For instance, crossing purple flowers with white ones typically produced purple offspring. However, two purple-flower plants sometimes produced white-flower offspring, proving that parental traits do not simply blend. *(Image Source)*



4. Summarize Mendel's claims, evidence, and reasoning.

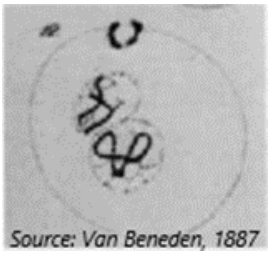
5. Summarize Hertwig's claims, evidence, and reasoning.

Hertwig's Eggs: By the late 1800s, microscopes allowed scientists to observe cells more closely. Oscar Hertwig studied how sperm fertilizes eggs in sea urchins. He saw the sperm's nucleus fuse with the egg's nucleus. Cell division (mitosis) began after this. All cells originated from this fertilized egg cell. This suggested that the contents inside the sperm and egg nuclei determined the traits of offspring. *(Image Source)*



6. Summarize Van Beneden's claims, evidence, and reasoning.

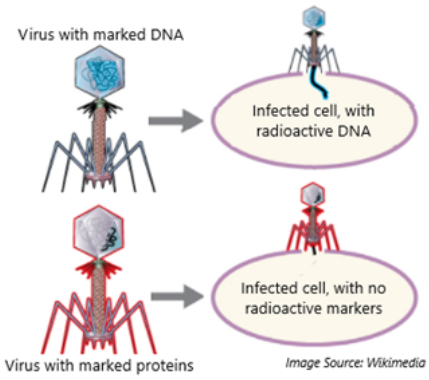
Van Beneden's Loops: A few years later, Edouard Van Beneden discovered that the nucleus of each cell contained "loops". When a sperm cell fertilized an egg, these *chromosomes* from both joined together, doubling the total number. Van Beneden hypothesized that chromosomes carry the genetic information that determines traits. *(Image Source)*



7. Summarize the claims, evidence, and reasoning of Hershey and Chase.

Hershey & Chase Go Viral: In the mid-1900s, scientists determined that chromosomes contained both proteins and DNA. However, they weren't sure which carried genetic information. Hershey and Chase used viruses to test this. Simple viruses have only two parts: protein and DNA. Viruses inject their genetic information into infected cells to make them produce more viruses.

Hershey and Chase added radioactive dyes to either the proteins or the DNA of the viruses. When the dye was attached to the proteins, it remained with the virus. However, when the dye was on the DNA, it entered the cell. This showed that the DNA carries the genetic information, not proteins.



8. Using all of the evidence and arguments in this reading, explain how offspring inherit the traits of their parents.

Data Dive 2 - *Read the directions below.* SEP: Analyzing & Interpreting Data

Data Dive 2: Purebred labrador retrievers can have a black, brown, or yellow coat. In these dogs, coat color is determined by two genes: Gene B and Gene E.

There are two *alleles* (or versions) of Gene B: *B* and *b*. There are also two alleles for Gene E: *E* and *e*. Uppercase letters represent *dominant* genes, while lowercase letters are for *recessive* genes. Dominant genes are always expressed if present. Recessive genes are only expressed if no dominant genes are inherited for that trait. Table 1 shows how different combinations of alleles for Gene B and Gene E result in different coat colors.

Table 1

Genotype	Coat color
BBEE	***black***
BBEe	***black***
BBee	***yellow***
BbEE	***black***
BbEe	***black***
Bbee	***yellow***
bbEE	***brown***
bbEe	***brown***
bbee	***yellow***

Table 2

Cross	Number of offspring with a: black coat	brown coat	yellow coat
1	8	0	0
2	6	1	2
3	2	2	2

Parents can only pass on one of their two copies for each gene. For example, a dog with genes *BbEe* could pass on four possible combinations: *BE*, *Be*, *bE*, or *be*. If an animal has two different alleles of a gene, there is a 50% chance that either version will be passed on to its offspring.

Two of the dogs with black coats mated three times (Crosses 1-3). They produced three separate litters of puppies. The coat colors of the offspring produced in each cross are shown in Table 2. *Source* - ACTExam.net

Individual Questions - *Complete the questions below individually.* SEP: Analyzing & Interpreting Data

1. **After Cross 2 but before Cross 3, a student hypothesized that each of the parents had the genotype *BBEE*. Was this hypothesis consistent with the results of Cross 2?**
   A. Yes, because all the offspring of Cross 1 had black coats.
   B. Yes, because all the offspring of Cross 1 had yellow coats.
   C. No, because some offspring of Cross 1 did not have black coats.
   D. No, because all the offspring of Cross 1 had yellow coat**s.**
2. **What was the Gene B and Gene E genotype of the offspring of Cross 2 that had a brown coat?**
   A. *bbee* B. *BBEE* C. *BbEE* or *BbEe* D. *bbEE* or *bbEe*
3. **Based on Tables 1 and 2, what fraction of the offspring of Cross 3 had one or more copies of the *E* allele of Gene E ?** A. ¼ B. ⅓ C. ⅔ D. ⅙
4. **Consider the offspring of each of the three crosses. Based on Tables 1 & 2, some of the offspring of which of the crosses, if any, could have had only recessive alleles of Gene B and Gene E ?**
   A. Cross 1 only B. Crosses 2 and 3 only C. Crosses 1, 2, and 3 D. None of the crosses
5. **Suppose two of the offspring from Cross 3 with yellow coats are crossed. What percent of the resulting offspring will have yellow coats?**
   A. 0% B. 25% C. 50% D. 100%
6. **If a dog has a specific combination of genes: *BbEE*, approximately what percentage of its offspring will inherit the *B* allele?** A. 0% B. 25% C. 50% D. 100%
7. **Further Discussion: How do genes from parents transfer to the cells of their offspring? What determines which genes the offspring get from their parents?**

Discussion - *Record your ideas in the spaces below.* *SEP: Asking Questions & Defining Problems*

What are the ideas that most agreed on? Where did your ideas differ as a class? Record your ideas below.

We generally agree that…	***We disagreed or were unsure if…***

Initial Explanations - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Designing Solutions*

How are traits inherited from parents? Write down an initial explanation below. Don't worry if you aren't completely sure about this. You will revise this explanation as you gain more information.

_____

_____

_____

Part 2: Core Ideas (5.2.2)

Overview: In this activity, you will use a short presentation to provide you with information that will help you improve and revise your initial ideas. Your instructor will decide on how to implement this portion. You will then work in small teams to address the questions listed below. You might also watch this video.

Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing & Using Models

1. What is the difference between sexual and asexual reproduction? What are the advantages and disadvantages of each?
2. How did low genetic diversity from asexual reproduction cause the Irish Potato Famine?
3. What is a gamete? Why is it important for sexual reproduction?
4. What is meiosis? How does it relate to gametes?
5. What is the difference between a diploid and haploid cell?
6. Why are gametes haploid? What would happen if a gamete was diploid?
7. How are mitosis and meiosis similar, and how are they different?
8. Why does a second round of division occur in meiosis? How does this affect the production of haploid gametes (sperm and egg cells)?
9. What is crossing over? How does it increase the genetic diversity of offspring?
10. How does crossing over relate to the genetic diversity and species survival rates?
11. What are linked genes? What determines if genes are linked?
12. Summarize how gametes change during fertilization.

Revising Explanations - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Developing Solutions*

How are traits inherited from parents? Based on this new info, how would you now respond?

_____

_____

Part 3A: Meiosis Simulation (5.2.3a)

Pre-Investigation Questions - *Work as a group to prepare verbal responses for these questions. When you think you are <u>all</u> ready to provide responses, raise your hand. Your instructor will listen to your explanations, provide feedback, and determine if you are ready to move on to the investigation.*
SEP: Developing & Using Models

1. What is the difference between sexual and asexual reproduction?
2. What is meiosis? What are gametes? How are these terms related?
3. How are mitosis and meiosis similar and how are they different?
4. What is crossing over? How does it increase the genetic diversity of offspring?

This activity was completed _____ (*instructor signature*)

Overview: You will be using a computer simulation to identify similarities and differences between mitosis and meiosis. You will then use this information to test your understanding of these concepts and why they occur.

Hypothesis - *Discuss your ideas and record your predictions in the spaces below.*
SEP: Planning and Carrying Out Investigations

1. In a moment you will observe mitosis and meiosis occur side-by-side in a simulation. Predict three ways in which the processes and outcomes of meiosis will differ from mitosis in this simulation:

   <u>1.</u> _____

   <u>2.</u> _____

   <u>3.</u> _____

Directions - *Carefully read the directions below <u>before</u> beginning.* *SEP: Developing & Using Models*

Methods: Check each box as you complete each step.

1. ☐ Using a school-approved device, visit this website: Meiosis Simulation
2. ☐ Adjust your settings so that you only have one pair of chromosomes, and so that crossing over is turned on. Leave the animation on, and only run one cycle.
3. ☐ Click "Run Simulation". Observe what occurs before recording any observations.
4. ☐ Click "Reset". Confirm you have the same settings as before. Be prepared to record your written observations based on the questions in the Results section. When ready, click "Run Simulation".
5. ☐ Record your observations and answer the questions in the Results section.

Results - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Developing Solutions*

1. **Complete the table below.** (*Note: each chromosome is shown as a single blue or red line*).

	Chromosome Number at Start	Chromosome Number at End	Cell Number at Start	Cell Number at End	Was DNA duplicated?	Did Crossing Over Occur?
Mitosis					Y / N	Y / N
Meiosis					Y / N	Y / N

2. **What are three ways in which the outcomes of meiosis differ from mitosis?**

3. **How does the chromosome number per cell differ after mitosis vs. meiosis? Why?**

4. **What kinds of cells are created through meiosis? What kinds of cells are created through mitosis?**

5. **Why is it necessary to have two kinds of cell division? What results from meiosis that cannot occur as a result of mitosis?**

6. **Which resulted in more genetic diversity - mitosis or meiosis? Defend your claim with evidence and reasoning.**

Part 3B: Meiosis Modeling (5.2.3b)

Overview: you will be using modeling clay (like Play Doh or Plastina) to model different aspects of meiosis, including crossing over.

Materials needed (per group of 4): at least 3 colors of modeling clay; scratch paper or a dry-erase board.

Methods: Check each box as you complete each step.

1. ☐ Acquire a piece of scratch paper or a dry erase board as well as a pen, marker, etc.
2. ☐ Use your notes to review the process of meiosis. You will need to model the following steps: A) Duplication of DNA. B) Condensing DNA into chromosomes. C) Attaching chromosomes to spindles. D) Crossing over between similar pairs of duplicated chromosomes. E) Separation of chromosomes. F) Initial cell division to create two diploid cells. G) Second separation of unduplicated chromosomes. H) Final cell division to create four haploid cells.
3. ☐ Work as a team to determine a strategy for showing these steps. You should be able to show all steps simultaneously. Hint: use two colors of clay for the chromosomes. Use a third color of clay for the spindles. Use the paper or dry erase board to draw circles that depict the cell membranes.
4. ☐ Determine which group members will explain each step of meiosis above using your models.
5. ☐ When ready, raise your hand and explain your work to your instructor. Be prepared to also address the following questions:
    a. What is the difference between mitosis and meiosis? How are they similar?
    b. Does meiosis enable sexual or asexual reproduction? What is the difference? What are the advantages and drawbacks of each?
    c. How does meiosis relate to gametes like sperm and egg cells?
    d. What is crossing over? How does it increase the genetic diversity of an organism's offspring?
6. ☐ Return items where needed based on your teacher's instructions.

This activity was completed _____ (*instructor signature*)

Part 4: Review & Assessment (5.2.4)

Step 1: Review each Driving Question. Circle any questions that are still unclear to you.
Step 2: Identify and discuss any remaining confusion with your instructor.
Step 3: Complete the Formative Assessment (individually or small groups). Compare responses as a class.
Step 4: Individually complete a Mastery Check. If needed, your instructor will provide further support.

Traits & Genes Packet 2 Formative Assessment (5.2.4)

Name: _____Hour____Date:_____Score:_____

Directions: A 3x5 notecard with *handwritten* notes can be used to guide your answers. Your instructor may allow you to work in assigned groups. If so, have a different person write each response while others assist.

1. **What is the difference between sexual and asexual reproduction? What are the advantages and disadvantages of each?**

2. **Do you agree or disagree with each student's claim?**
   Bristol: "I think that individuals mostly get either their mother's or father's genes." *Agree / Disagree*
   Nina: "I think that the traits of offspring are a mix of the traits of the parents." *Agree / Disagree*
   Darryl: "I think that offspring equally receive half of each of their parent's genes." *Agree / Disagree*

   Which claim(s) seems most accurate? _____Why? _____

3. **Explain what a gamete is and how it is formed during meiosis.** Include and underline the terms *diploid* and *haploid*.

4. **During meiosis, one regular cell will eventually form four haploid cells, each with a different set of DNA. Use the term crossing over to explain how one cell can form four genetically unique cells.**

5. **Animals with tame temperaments also tend to have floppy ears and short noses. Wild animals tend to have pointed ears and long noses (see the images below). Why does this occur? Do short noses and floppy ears make animals tame? Explain.** Include & underline the term *linked genes*.

Part 5: Life Connections – Sex-linked Traits (5.2.5)

Overview: For this activity, you will consider three claims about color blindness. You will then use a one-page reading to determine if your initial ideas are supported by evidence.

Initial Ideas - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Engaging in Argument from Evidence

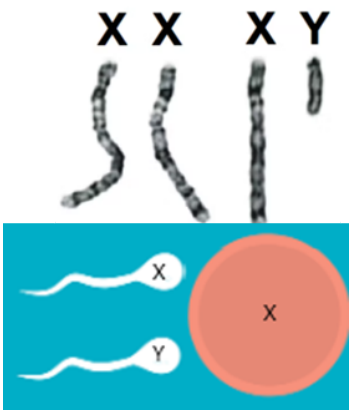
1. Oscar has learned he is color blind, and that this condition is far more common among men. Oscar doesn't understand how he could have this trait as neither of his parents are color blind (although his grandfather is). **Do you agree or disagree with each claim**?

- Oscar: I think that the cells in the eyes of males work differently from females, which results in an increased risk of some problems like color blindness. *Agree / Disagree*
- Avery: I think that some genes are only inherited from the mother's side of the family and these sometimes skip a generation somehow; maybe this is one of those traits(?) *Agree / Disagree*
- Nina: I think it involves X and Y chromosomes. However, I thought that this determined a person's biological sex, so I don't know how that could also affect their eyes. *Agree / Disagree*

2. **Work in your small groups to discuss your ideas.** Decide as a group whether each statement is correct (and why). Be prepared to present your ideas to the class. If time allows, consider watching this video as a class.

Reading - *Complete the reading below. Use the space on the right to annotate the text by recording your ideas, highlighting important points, and recording questions as you are reading.*
SEP: Obtaining, Evaluating, and Communicating Information

Background: Human cells usually have 46 chromosomes. Each parent contributes 23 chromosomes. The first 44 chromosomes are called *autosomes*. These are the same in both males and females. The last pair are called *sex chromosomes*. Females typically have two X chromosomes. Males usually have one X and one Y chromosome.



The SRY gene is found only on the Y chromosome. This gene is what causes male traits. A person's biological sex is mostly determined by whether a person inherits a SRY gene. Because an egg cell can only give an X chromosome, the sperm cell from the father usually determines the biological sex of human offspring.

Exceptions to XX & XY. Although most individuals have XX or XY chromosomes, variations can occur. For example, in *Swyer syndrome*, a Y chromosome with a non-working SRY gene can result in someone who has male chromosomes (XY) but female traits. Another example is *XX male syndrome*, where the SRY gene moves to an X chromosome. This results in a female chromosome pattern (XX) but male traits. These conditions are generally only discovered through genetic testing and often are unknown.

Driving Questions:
1. **What determines biological sex?**

2. Can someone have sexual traits that differ from their sex chromosomes? How?

3. **What are Swyer syndrome and XX male syndrome? How do these occur?**

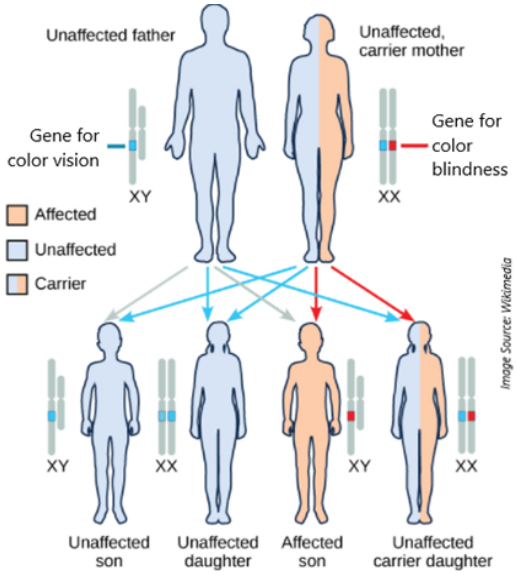
Sperm cells can sometimes carry extra sex chromosomes. This occurs in *Klinefelter syndrome*, where an individual inherits two X chromosomes and one Y chromosome. This can lead to a mix of male and female traits.

Other Factors. In addition to genes and chromosomes, hormonal changes during pregnancy can influence traits like behavior, cognitive abilities, and even sexual orientation. These hormonal effects suggest that biological sex traits are shaped not just by genetics but also by the hormonal environment during pregnancy.

Sex Linked Traits. The X chromosome has over 1400 genes, but the Y chromosome only has 158. This means people with XY chromosomes inherit some genes only from their mother. These are *sex-linked genes*.

This explains why color blindness is far more common among males than females. Women with XX chromosomes can carry the colorblindness gene without being colorblind (you only need one functional gene to see color).

People with XY chromosomes inherit only one copy of the color vision gene, which they get from their mother. If the mother passes on a colorblind gene, the son's single copy will be defective, causing color blindness. In contrast, individuals with XX chromosomes are less likely to be colorblind - they must inherit a colorblind gene from both parents for the condition to occur.



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4. **What is Klinefelter syndrome? How does it occur?**

5. **Are there factors outside of genes and chromosomes that can affect sex-related traits?**

6. What are sex-linked traits?

7. Why are most color-blind individuals male?